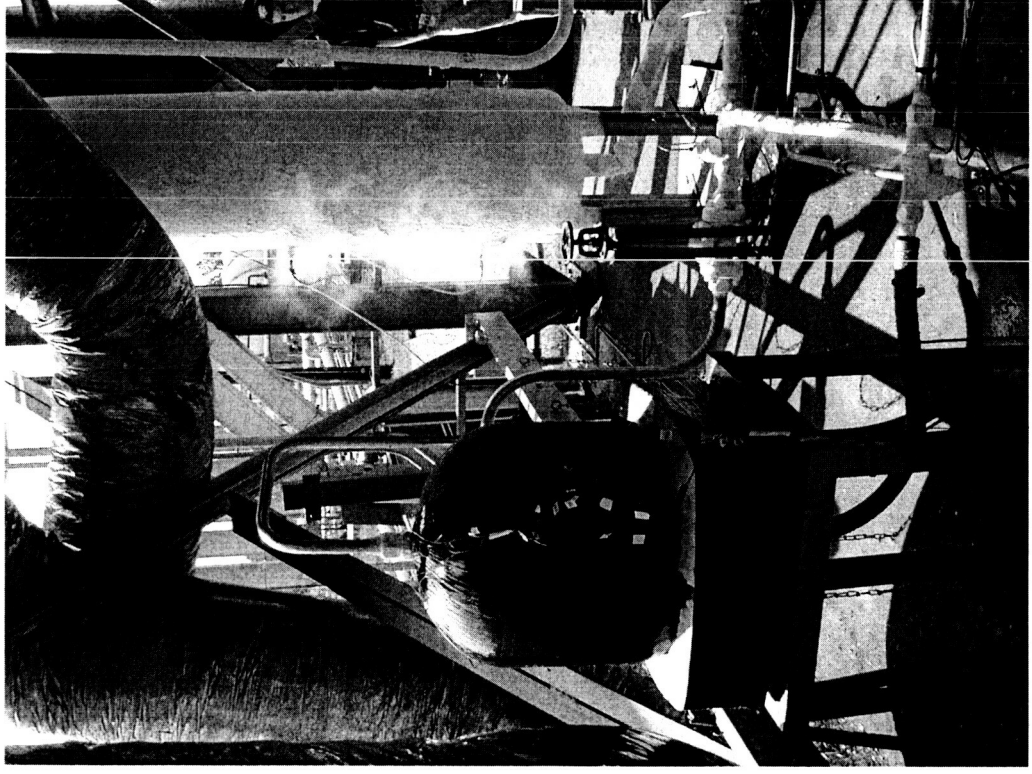
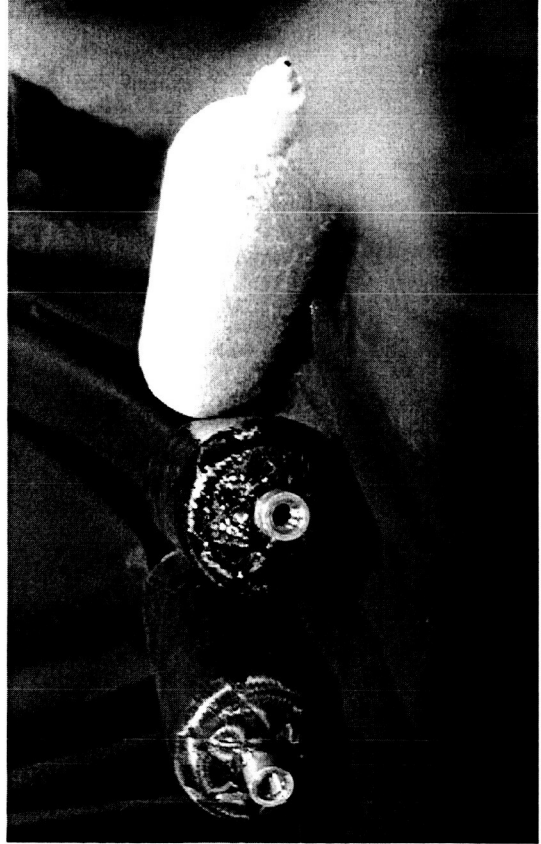


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Composite Tank Technologies Development

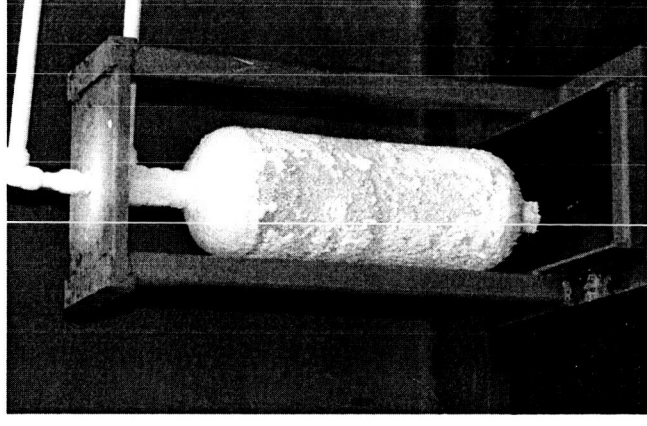
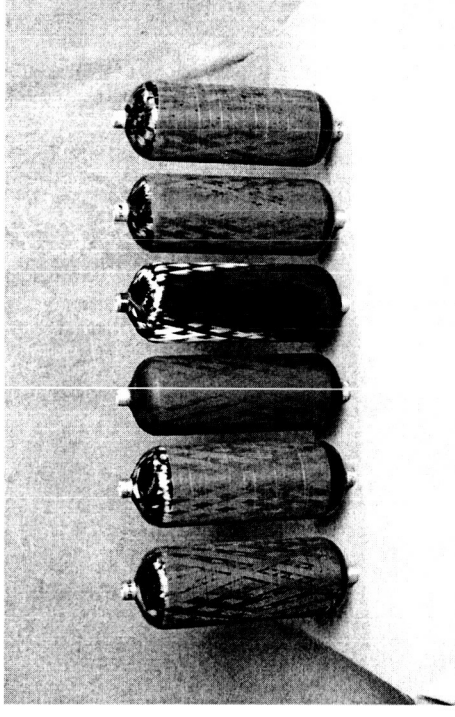
- Tom DeLay
- NASA/MSFC
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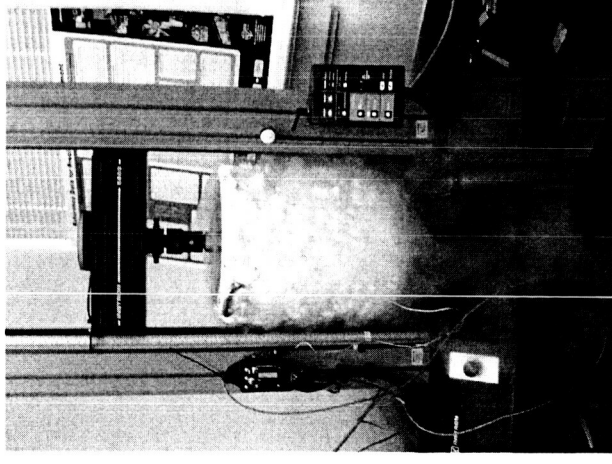
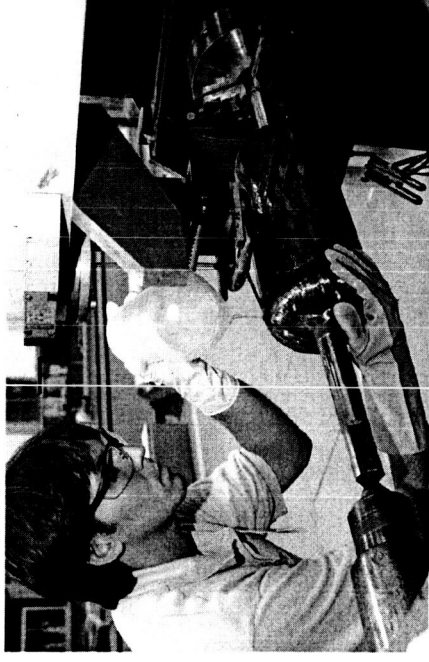


- The need for cryogenic fuel tanks continues to expand
 - ESR&T (Exploration Systems Research and Technology) program has the need for a Cryogenic Propellant Storage System with a Zero Boil-Off
 - Future Lunar and Mars Exploration Missions may utilize liquid oxygen and liquid methane
 - New crew exploration vehicle may need cryogenic fuel depots(LH2, LOX)
 - Deep space ion propulsion systems may utilize liquid Xenon, etc
 - Commercial alternate fuel efforts involve cryogenic tanks
 - Transport of liquefied natural gas in super-tankers
 - Use of liquefied natural gas for trucks and busses
 - Liquid hydrogen storage for cars
- Research at NASA is addressing these needs
 - New tank materials and process development
 - Extensive cryogenic tank testing

- Subscale tank testing approach
 - Utilize actual COPVs to understand material performance
 - Test vessels at ambient and cryogenic conditions
 - Relate test tank performance to material test samples
 - Repeat process with more testing
 - Down-selected tank materials used for high-cycle fill and drain with pressure
 - Lab support and analysis
 - Fabricate all-composite linerless vessels
 - Repeat cryogenic cycle testing
 - Lab support and NDE



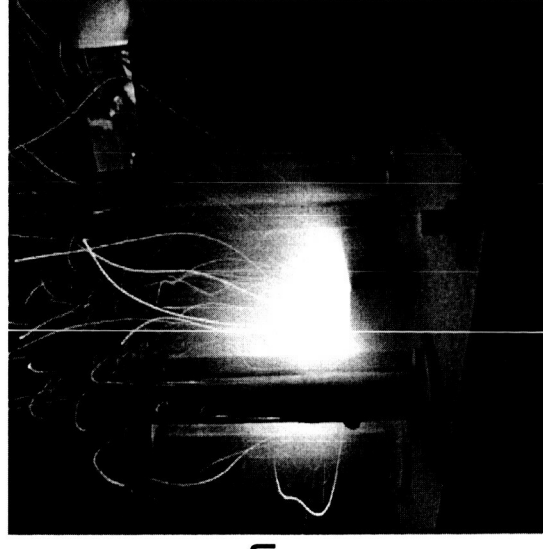
- Cryogenic materials research
 - Formulate matrix resins specifically for cryogenic applications
 - Epoxy, Cyanate ester, Polyurethane etc.
 - Compare new resins to commercially available materials
 - Cryogenic tensile testing of nest resin samples
 - Short-Beam Strength testing(cryogenic)
 - Relate coupon data to tank tests
 - Cryogenic fiber testing
- A new composite material has been developed
 - Good performance on COPV tests with liquid nitrogen, liquid hydrogen tests on horizon
 - Additional tests this summer
- Potential partnerships
 - NDE studies
 - Cryogenic impact damage
 - Radiation effects





Liquid oxygen tank development

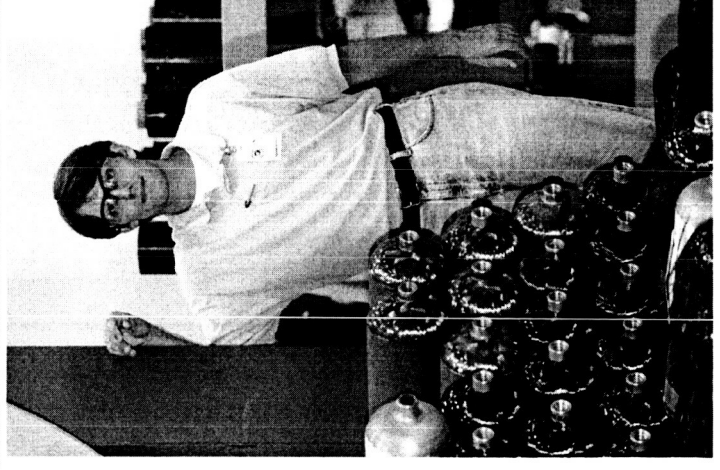
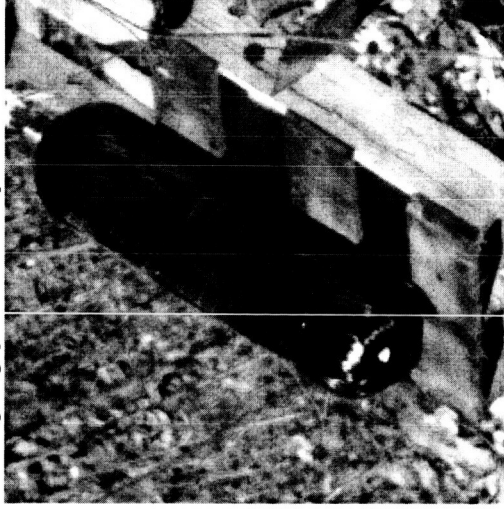
- An all-composite liquid oxygen tank is being developed for an ESR&T funded Zero-Boil-Off cryogenic propellant storage system
 - Goal of 85% reduction of mass, 50% cost reduction
 - Joint research effort including:
 - JPL, NASA Marshall, NASA Glenn, CTD Inc. HyPerComp eng. Inc.
 - Materials evaluated for liquid oxygen compatibility
 - New material development
 - Liquid oxygen compatible matrix resins
 - Permeability enhancement with nano-materials
 - Sub-scale test tanks cryogenically cycled
 - Full-size tank incorporated in the Zero-Boil-Off system





Leveraging partnerships

- Research is leveraged with university and industry partnerships
 - Mississippi State University materials testing
 - NCAM funded university research programs
 - Materials development, micro-crack studies
 - SBIR&STTR
 - Cryogenic material research
 - Impact damage resistance(Hybrid structures)
 - Cryogenic tank testing
 - Radiation effects on COPVs
 - Exploration Systems Research and Technology (ESR&T) funded projects
 - Relate test tank performance to material test samples

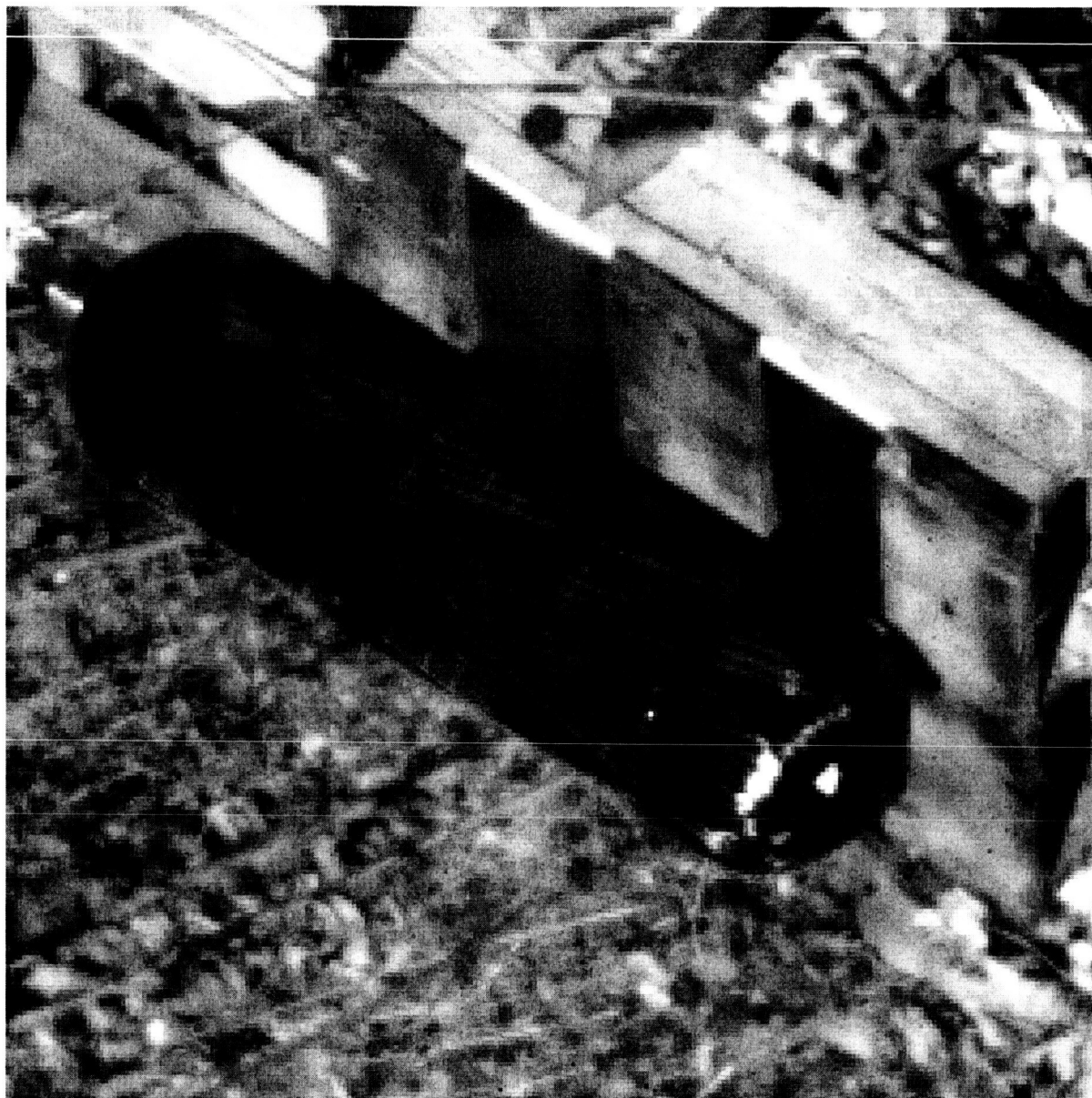


MPFES v. deer clip, 50 cal. bullet test

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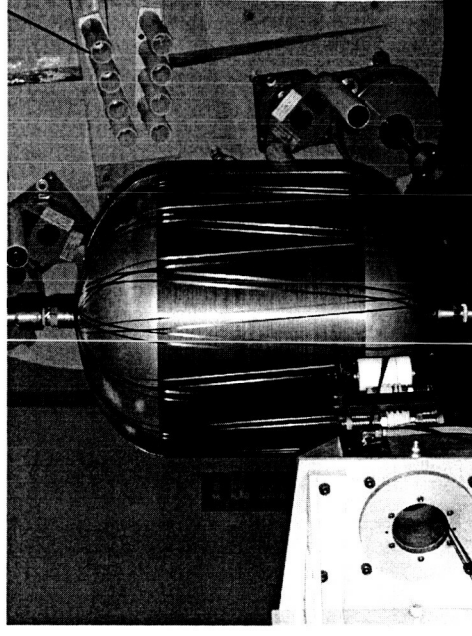
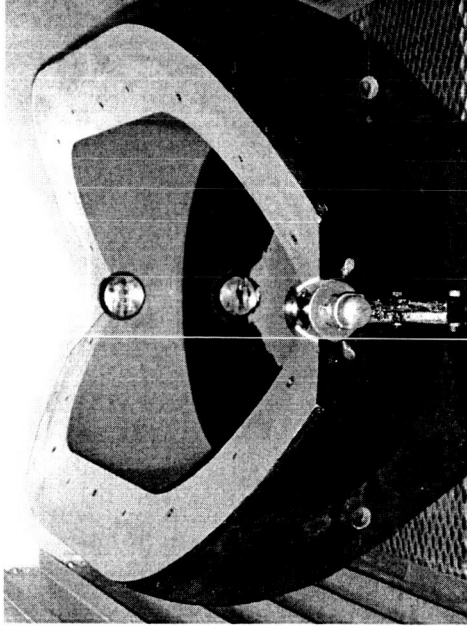


Composite Tank Development for Cryogenic Applications



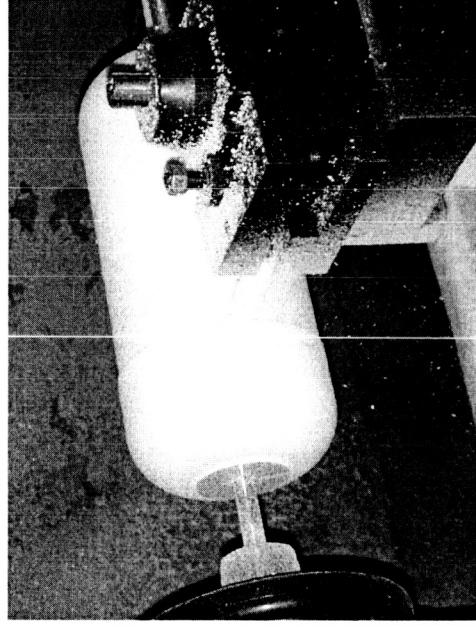
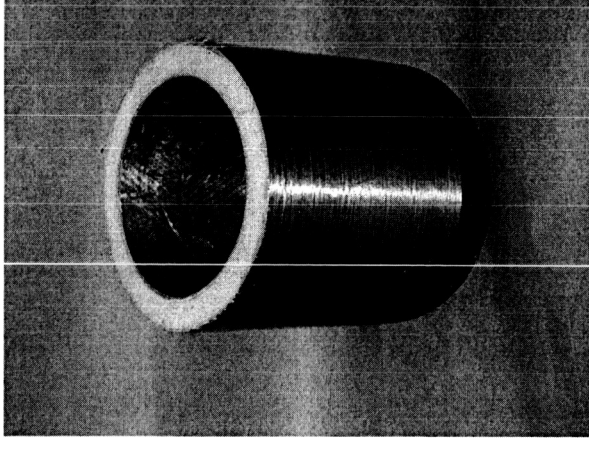
Liner concept development

- Ultra-light tank liners
 - Electro-formed metal liners
 - 10 mil thick permeation barriers
 - Pressure stabilized during winding and cure
 - Ambient and cryogenic pressure testing
 - JPL chem-milled aluminum liner
 - Thermally sprayed non-metals
 - Material gradients
 - Thermoset or thermoplastic layer over-wrapped with structural composites
 - Hybrid materials
- Dual walled tank development

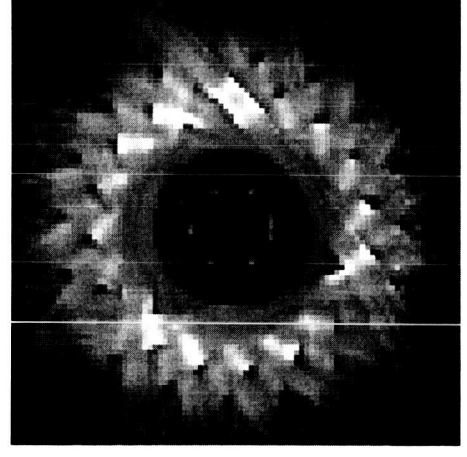
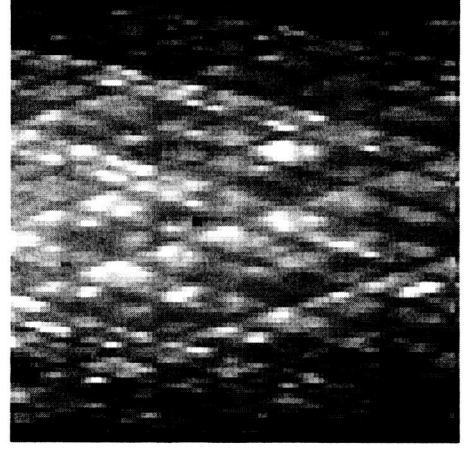
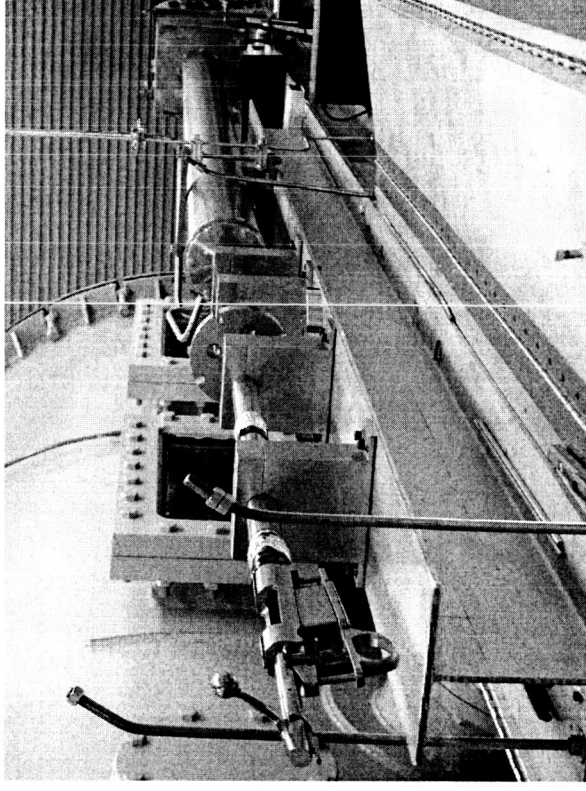


- Dual walled tank technology
 - Applicable to many system concepts
 - Metallic permeation barrier with composite over-wrap
 - Cryogenic insulation over-wrapped with damage tolerant composite layer
 - Provide impact resistance and insulation
- LNG tank concept
 - COPV with cryogenic composite over-wrap material
 - Vessel encapsulated in insulation materials
 - Sensors mounted on vessel wall
 - Insulation material covered with protective coating
 - Environment protection
 - Impact damage tolerance
 - Similar vessel currently incorporated in a liquid methane propulsion system test bed

Other tank concepts



- Other research
 - Space environments
 - Hypervelocity impacts
 - Cryogenic cycling for long term storage
 - Radiation effects
 - Cryogenic impacts
 - DOT and military tests
 - Drop test
 - 30 caliber, 50 caliber bullet
 - Bon-fire testing
 - NDE studies
 - Fiber optics
 - Acoustic emissions
 - Thermography
 - others
 - Tooling development

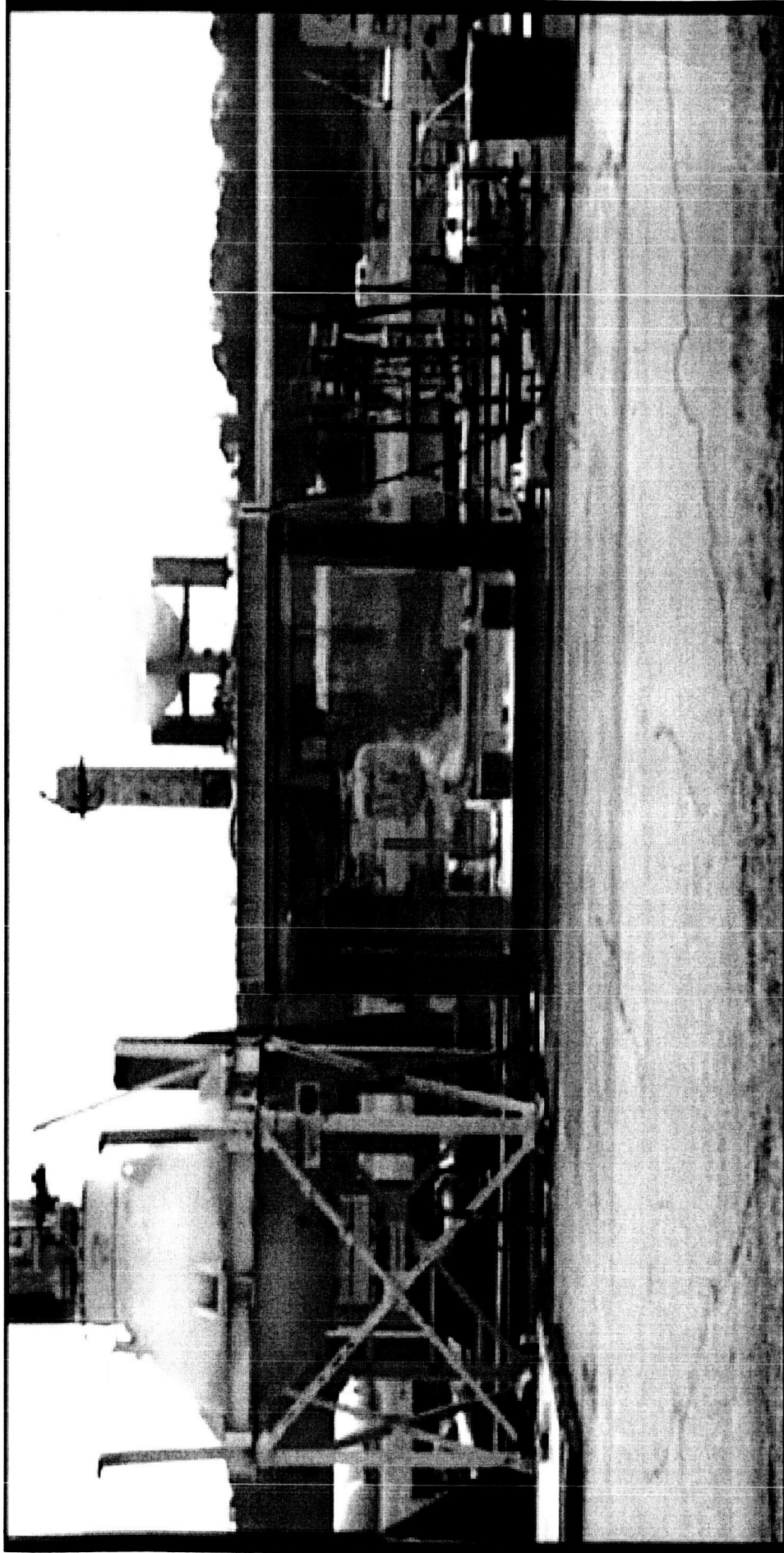




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Composite Tank Development for Cryogenic Applications

MPFG Video clip





TECHNOLOGY TRANSFER DEPARTMENT

Seek and invite industry partners to license government owned technologies, and to utilize government facilities for the purpose of developing and perfecting manufacturing fabrication technologies.

FOR MORE INFORMATION CONTACT:

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